EMI Considerations

General Application Note 100

Revised 01MAY2002

Conducted Noise and Emissions.

This note is intended to provide additional EMI information not addressed in individual datasheets. Specifically, it provides information required by the designer to properly design the end application such that it will meet conducted noise requirements of the FCC and EN55022.

Most applications are required by regulatory agencies to meet certain maximum conducted emissions levels. EN55022 and FCC Title 47 are typical examples of these requirements.

The following figures and associated tables show required typical connections for –48 V systems using the di/dt single and dual output converters. Refer to the figures below and the associated table following for external components used to provide compliance.

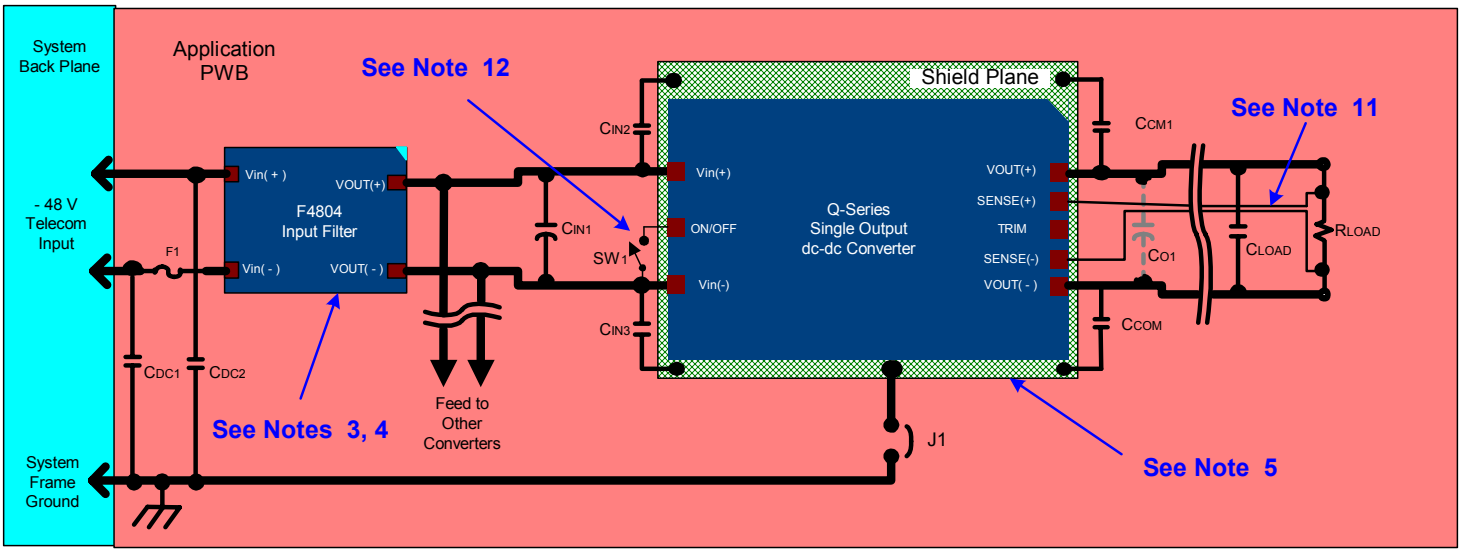

Fig. 1: Q-series single output converter mounted on a typical application board
Showing filter and all external components required to meet FCC or EN55022 Class B conducted requirements
Viewed from component side looking through Q-series converter

Note: PWB designs for modern telecommunication and data communication application boards typically use multiple layer planes of continuous copper for routing of the –48V, –48V-return, and frame ground connections within the board. Use of multiple planes decreases board losses and EMI levels.

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Table 1 – Single Output Converters – see Fig. 1			
Circuit Reference	**Description**	**Typical Value**	**Notes**
F1	Input Fuse	See datasheet for individual fuse ratings. (Littelfuse, Nanofuse SMF series)	1
C_{DC1}, C_{DC2}	PWB level input common-mode EMI suppression capacitors	3300-4700 ρF, ceramic, 1500-2500V.	2
C_{IN1}	Input capacitor	47 µF aluminum electrolytic for Class B.	3
C_{IN2}, C_{IN3}	Converter level input common-mode EMI suppression capacitors	1000-4700 ρF, ceramic, 1500-2500V.	8, 9,10
SW_1	Remote ON/OFF	Switch for controlling converter ON/OFF function. Typically a FET or opto-isolator. (Not EMI affecting component)	11
J_1	Jumper between shield plane and system frame ground.	See notes below.	6
C_{O1}	Output bulk capacitance	Optional, typically not needed to meet EMI or datasheet specifications; however use of a 47uF ceramic can reduce output noise and ripple to less than 10 mV at full load.	7
C_{CM1}, C_{COM}	Output common-mode EMI suppression capacitors	1000-4700 ρF, ceramic, 1500-2500V.	8, 9, 10

Notes:

1. As shown, F_1 is intended to protect multiple converters (inputs paralleled) Q-series is safety rated by UL and TUV for use with as large as a 15 A fuse.
2. Board level de-coupling capacitors, C_{DC1}, C_{DC2}, are typically located on PWB directly after backplane connector, decouples CM noise present on dc distribution bus.
3. An input filter similar to the F4804 input filter (available from di/dt, Inc.) is required to meet EN55022/FCC Class B conducted requirements. See page 3 for typical filter circuit schematic.
4. No input filter is required to meet EN55022/FCC Class A conducted requirements; however, the value of input capacitor, C_{IN1} must be increased to ~200 uF.
5. A shield plane, if used, should be buried in an internal board layer to prevent any electrical ISOLATION issues with converter placement and to maintain creepage distances between input and output. The shield plane may not be required for all applications.
6. Jumper J_1 can be implemented to allow connection of shield plane to system frame ground, if EMI tests warrant the connection. Typically, J_1 is not connected; however, having the capability is good practice.
7. Converter design can support significantly higher output capacitance values; refer to specific datasheet for maximum specification.
8. Pads for EMI capacitors C_{IN2}, C_{IN3}, C_{CM1}, and C_{COM}, should be included in a layout, but all may or may not need to be populated, depending upon EMI environment of system.
9. When no shield plane is specified, capacitors pairs C_{IN2}+C_{CM1} and C_{IN3} + C_{COM} may be replaced with single capacitors connected between the respective input and output terminals. In this case, the equivalent capacitance for the C_{IN2}+C_{CM1} pair will be ~4500 ρF, and for the C_{IN3} + C_{COM} pair, ~6000 ρF. Care should be used in connecting capacitors between input and output of the converter, depending upon the input-output isolation required by the application.
10. Voltage rating for capacitors connected from primary to secondary (via a shield plane or not) depends upon the level of isolation required by safety agency requirements. If full isolation is required, each capacitor (C_{IN3}, C_{IN4}, C_{O2}, C_{O3}) should have a minimum rating of 1500 V. Otherwise, voltage ratings may be lower. Designer must verify system safety requirements.
11. If used, route sense leads tightly to one another to avoid extraneous noise pick-up.
12. Multiple converters can be controlled with one switch; however, in order to avoid marginal turn-on and associated noise issues, be sure switch capacity is sufficient to allow pull down of ON/OFF pin(s) to levels stated in datasheet.

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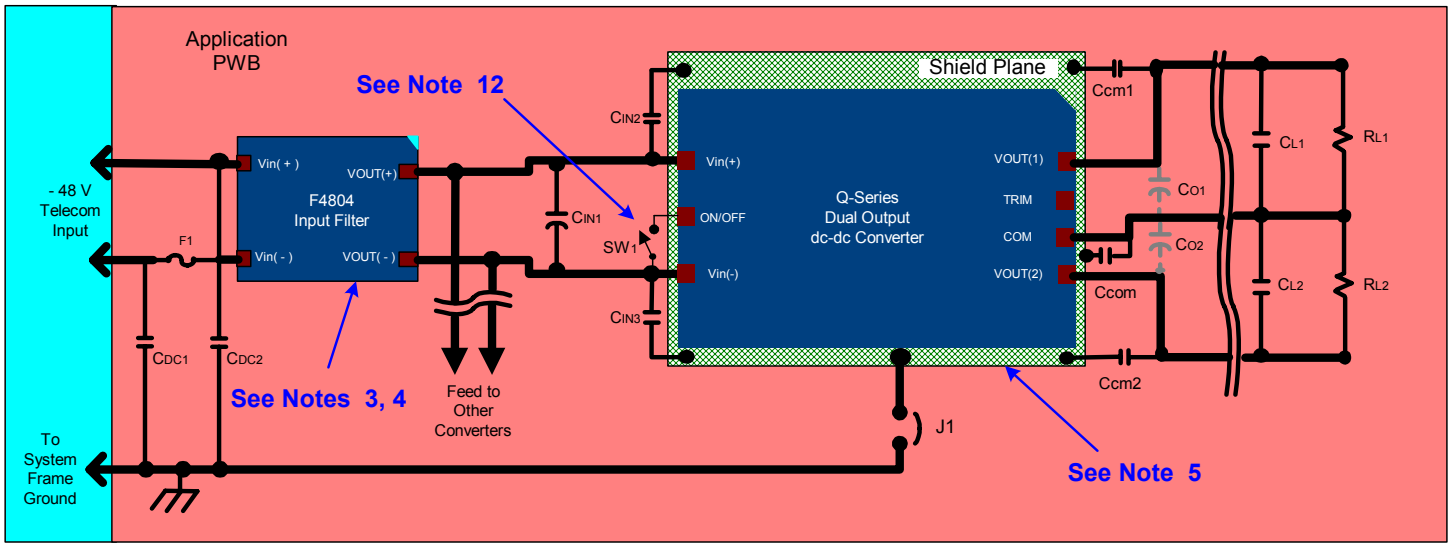

Fig. 2: Q-series dual output converter mounted on a typical application board
Showing filter and all external components required to meet FCC or EN55022 Class B conducted requirements
Viewed from component side looking through Q-series converter

Note: PWB designs for modern telecommunication and data communication application boards typically use multiple layer planes of continuous copper for routing of the –48V, –48V-return, and frame ground connections within the board. Use of multiple planes decreases board losses and EMI levels.

Table 2 – Dual Output – see Fig. 2			
Circuit Reference	**Description**	**Typical Value**	**Notes**
F1	Input Fuse	See datasheet for individual fuse ratings. (Littelfuse, Nanofuse SMF series)	1
C_{DC1}, C_{DC2}	PWB level input common-mode EMI suppression capacitors	3300-4700 ρF, ceramic, 1500-2500V.	2
C_{IN1}	Input capacitor	47 µF aluminum electrolytic or ceramic for Class B.	2
C_{IN2}, C_{IN3}	Converter level input common-mode EMI suppression capacitors	1000-4700 ρF, ceramic. 2.5 kV	7, 8, 9
SW_1	Remote ON/OFF	Switch for controlling converter ON/OFF function. Typically a FET or opto-isolator. (Not EMI affecting component)	10
J_1	Jumper between shield plane and system frame ground.	See notes below.	5
C_{O1}, C_{O2}	Output bulk capacitances	Optional, typically not needed to meet EMI or datasheet specifications; however use of a 47uF ceramic can reduce output noise and ripple to less than 15 mV at full load.	6
C_{CM1}, C_{CM2}, C_{COM}	Output common-mode EMI suppression capacitors	1000-4700 ρF, ceramic, 2.5 kV	7,8, 9

Notes:

1. As shown, F_1 is intended to protect multiple converters (inputs paralleled). Q-series is safety rated by UL and TUV for use with as large as a 15 A fuse.
2. Board level de-coupling capacitors, C_{DC1}, C_{DC2}, are typically located on PWB directly after backplane connector, decouples CM noise present on dc distribution bus.
3. An input filter similar to the F4804 input filter (available from di/dt,Inc.) is required to meet EN55022/FCC Class B conducted requirements. See page 3 for typical filter circuit schematic.
4. No input filter is required to meet EN55022/FCC Class A conducted requirements; however, the value of input capacitor, C_{IN1} must be increased to ~200 uF.
5. A shield plane, if used, should be located in an internal board layer to prevent any electrical isolation issues due to converter placement and to maintain safety agency creepage distances between input and output. The shield plane may not be required for all applications.
6. Jumper J_1 can be implemented to allow connection of shield plane to system frame ground, if EMI tests warrant the connection. Typically, J_1 is not connected; however, having the capability is good practice.
7. Converter design can support significantly higher output capacitance values; refer to specific datasheet for maximum specification.
8. Pads for EMI capacitors C_{IN2}, C_{IN3}, C_{CM1}, C_{CM2} and C_{COM}, should be included in a layout, but all may or may not need to be populated, depending upon EMI environment of system.
9. When no shield plane is specified, capacitors pairs $C_{IN2} + C_{CM1}$ and $C_{IN2} + C_{CM2}$, and $C_{IN3} + C_{COM}$ may be replaced with single capacitors connected between the respective input and output terminals. In this case, the equivalent capacitance for the $C_{IN2} + C_{CM1}$ and $C_{IN2} + C_{CM2}$ pairs will be ~4500 ρF, and for the $C_{IN3} + C_{COM}$ pair, ~6000 ρF. Care should be used in connecting capacitors between input and output of the converter, depending upon the input-output isolation required by the application.
10. Voltage rating for capacitors connected from primary to secondary (via a shield plane or not) depends upon the level of isolation required by safety agency requirements. If full isolation is required, each capacitor (C_{IN2}, C_{IN3}, C_{CM1}, C_{CM2}, C_{COM}) should have a minimum rating of 1500 V. Otherwise, voltage ratings may be lower. Designer must verify system safety requirements.
11. Multiple converters can be controlled with a single ON/OFF switch; however, in order to avoid a marginal turn-on condition and associated noise issues, be sure switch capacity is sufficient to allow pull down of ON/OFF pin(s) to levels stated in datasheet.

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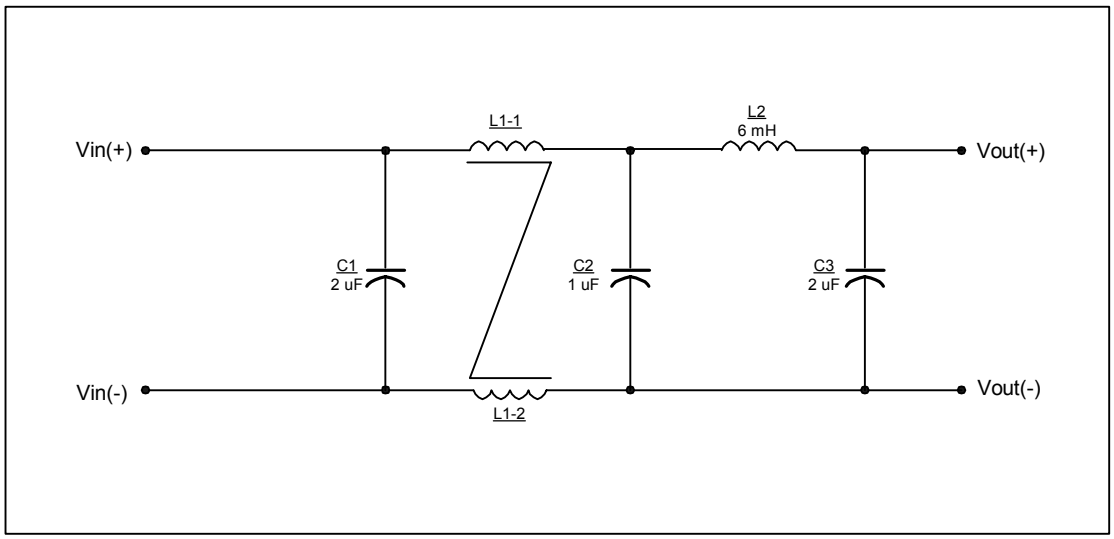

Typical Input Filter Schematic (suitable for 24 or 48 V input converters)
Common-mode capacitors are not shown; see Table 1 Notes for details.

Schematic Notes:

1. C1 and C3 are 2 X 1µF; C2 is a single 1 µF, all are ceramic rated at 100 V.
2. LI is a common-mode choke, TDK ACM 0908–801–2P
3. L2 is a differential-mode inductor, Vishay, IHLP–252CZ–01, 5.0 uH
4. Parts list as shown is capable of supporting of up to 4A of load.

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